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Transfer of Biocontrol Technology in Taiwan

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ABSTRACT

Applied biological control (biocontrol) involves the use and management of natural enemies of plant pests by humans. Its advantages over other types of controls includes its relative safety, permanence, and economy. One minor disadvantage is that a biocontrol program may take a long time to implement, because of the research and other efforts involved in setting it up. The best natural enemy is one that is an exceptional searcher and has high fecundity, and thus it is able to find the host or prey at very low densities and thus help maintain those low levels. The lacewing is a broadly used natural enemy. It preys on aphids, psyllids, mealybugs, whiteflies, spider mites, and the crawlers of scales. The lacewing Mallada basalis (Walker) is an indigenous species which is a natural enemy of spider mites, mulberry psyllids, and peach aphids in Taiwan. It has been successfully reared in great numbers using the eggs of the rice moth, Corcyra cephalonica (Stainton), as food and has been applied to biocontrol of spider mites on papaya and strawberry. The main extension method begins with a demonstration conference, and then individual discussion meetings are held with interested production and marketing groups to transfer the rearing techniques. Extension agents make continual follow-up visits to help group members solve technical problems during the period of technology transfer.

Introduction

A species population is "regulated" by the combined action of biotic and abiotic factors at a characteristic fluctuating level that is called natural control or the balance of nature. This fluctuation may vary from one geographic area to another, or may change with time in the same area as conditions change. The more diverse the natural communities are in an area, the greater the ranges of compensations which exist for preventing drastic upsets which may cause controlling agents to temporarily lose their effectiveness. Oversimplified agro-ecosystems create relatively unstable environments which give rise to a greater

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magnitude of variation in numbers of pests.

"Regulation" implies that fluctuation levels are restricted by density-induced factors called density-dependent factors, such as the properties of the species and natural enemies. On the other hand, climate, soil, and photoperiod are unrelated to density and are regarded as density-independent factors. These factors have the same effect on numbers regardless of the density.

The term "biological control" is commonly used to signify the use of natural enemies to control pests. An insect becomes a pest as a result of its escape from the balance of nature which exists in its native habitat, where living organisms have experienced long-term coevolution and are affected by similar biotic and abiotic factors. High population levels of an invasive insect can be reduced by a reconstitution of this balance in the new habitat based on the introduction and manipulation of its natural enemies. However, it is neither possible nor desirable with biological control to reconstruct the complicated interactions among pests and their natural enemies or the environment. Effective biological control requires that the pest population be regulated to an extent that it does not exceed an economic injurious level, or so that it can be reduced with some other form of integrated control methods. Therefore, one is concerned not so much with how a natural enemy actually performs in its native habitat as with its intrinsic properties and their expression in the new ecosystem. Once biological control is successfully established, it is often self-perpetuating at little or no cost, with no harmful effects to humans, plants, or other organisms. But special caution is required since the impact on the native living beings of introducing a foreign organism into a new ecosystem is difficult to indicate or forecast without greatly expanded research over a long period.

Is Biological Control Feasible?

In order to answer this, each of the following questions should be taken into consideration.

1. How much injury is tolerable?

This aspect concerns society's needs and desires. If consumers tend not to accept damaged products to the extent that little or zero damage is tolerated, then biological control is severely limited. Natural enemies cannot prevent all damage by a pest since they tend to interact with the pest at equilibrium densities.

2. What is the value of the crop?

The cost/benefit ratios may dictate the control method for a pest problem. In the control of pests or weeds on low-value cash crops, the introduction of natural enemies to self-regulate the system may be an economically viable approach.

3. Is the crop annual or perennial?

To achieve biological control of pests on annual crops is more difficult because of the instability of annual crop agricultural systems. Generally, pests invade the crop field before the natural enemies and have higher reproductive capacities. By the time the natural enemies have become established and begun to express their control effects on pests, the crop is ready to be harvested and could be damaged. Hence an inundatory release of natural enemies is necessary to control the pest in a timely manner much as insecticides do, but that increases the cost/benefit ratio.

4. Is the pest native or foreign?

If the pest is foreign, the first approach is to investigate the natural enemies that attack it where it naturally occurs. If it is native, the management of its existing natural enemies can be investigated along with the possibility of importing exotic ones.

5. Are there any effective natural enemies?

Whether or not one natural enemy by itself or several used in combination can maintain the pest population at below an economic injurious level is hard to predict. In some cases, because of the ecological homeostasis between a pest and its natural enemies, the possibility of introducing better control organisms needs to be considered.

6. How many pests must be controlled and what level of control is required?

If there are numerous pest species and damage tolerance is low for a crop, a wide scope of insecticides may be necessary, since the use of natural enemies to control some of the pest species can be too complicated to be economically studied.

7. Are selective insecticides or resistant natural enemies available?

The use of selective insecticides will help to conserve populations of natural enemies while killing the pest in the field. Other considerations for keeping the insecticides away from natural enemies include the careful use of dosage, timing, application, and formulation. Insecticide-resistant natural enemies can be obtained through a careful manual screening process and used in such situations that one or more pests must be controlled by frequent and/or heavy insecticide applications.

8. Has the same control program been successful in other areas?

The practice of biological control has essentially had an empirical, not a theoretical, origin. A similar successful biological control program can be expected against the same pests on the same crops under similar conditions.

Transfer of Biocontrol Technology

1. The lacewing

The young stages (larvae) of the lacewing look like small alligators and are voracious predators. Larvae prey on a variety of insects such as spider mites, aphids, whiteflies, mealybugs, thrips, leafhoppers, psyllids (jumping plant lice), and the eggs or young stages of lepidopterans and coleopterans. The larva uses its piercing mouthpart to suck out the body fluid of its victims. The emptied victim's body is then carried on the back of the larva to act as camouflage, as it looks like bird feces. In contrast, the adult lacewing feeds only on nectar and pollen. The entire life cycle is about 6 weeks, with the young stage ranging from 12 to 25 days. Over 20 companies worldwide supply lacewing eggs for the control of insect pests on strawberry, hops, pepper, tomato, lettuce, and ornamentals grown outdoors and in greenhouses.

Mallada basalis (Walker) is a native species of lacewing in Taiwan. Research on its biology and rearing techniques began in 1975. But techniques for its mass-rearing were not successfully established until a stable supply of the eggs of rice moth, *Corcyra cephalonica*, was available. The Taiwan Research Institute of Sugar rears copious amounts of rice moths and collects the moth eggs for the purpose of reproducing a *Trichogramma* parasitoid that is used for the control of corn earworms.

The Miaoli District Agricultural Research and Extension Station invented a new rearing technique based on years of research experience on this predatory lacewing. The larvae are fed with moth eggs in an insectary. The inside edges of the rearing containers (45 x 30 x 15 cm) for the larvae are painted with fluon (polytetrafluoroethylene, ICI) to prevent the larvae from crawling away. Adults are contained inside a transparent PVC cylinder, which has a sheet of white paper encircling the interior for egg collection. The entire cylinder is placed on a garden watering plate so that it can easily be moved around. The adults are fed with a mixture of yeast and honey, and a piece of cotton saturated with water in a film canister serves as a water source. A working table with a fan mounted underneath is used to manipulate the adults. The face of the fan is covered with a net and is mounted in the center on the same level as the table. The adults are immobilized on the net and cannot fly away, as the fan spins in reverse and draws them onto the net.

The lacewing was first released to control citrus red spider mite, *Panonychus citri*, on citrus on a small scale in 1991. It was later widely released for the control of spider mites on net-housed papaya and strawberry, and for aphids on lettuces and ornamentals. Researchers worked with farmers when studying the efficiency of a control agent on a specific crop grown within the Miaoli District. It takes a few years to confirm the effects of a control agent by itself or in combination with other control methods on a target pest.

The first step in transferring a successful pest control technique to farmers is to hold a demonstration conference to bring farmers together. In the conference, the participatory farmer describes what he has experienced with the use of a natural enemy for insect pest control on his crop. Researchers also play the role of extension agent to some extent. They later hold individual discussion meetings with interested production and marketing groups. Those group members usually grow the same crops or fruit trees. A member of the group is responsible for reproducing the natural enemy and then sells it to other members. At this stage, the Miaoli Station provides the stock source of biocontrol agents for the group to reproduce more individuals, that are later all released on crops for pest control. The central government provides subsidies for the food of the natural enemy through an extension program for biological control.

2. The predatory stinkbug

The stinkbug, *Eocanthecona furcellata* (Wolff), is a common predator on vegetable fields in Taiwan. Its biology and control potential for pests was first studied in 1971. It was also studied for controlling the young stage of leaf beetles in Meghalaya in 1996. The young stages of this predator can kill up to 22 caterpillars of the third stage of the Chinese cabbage butterfly every day. Each adult female killed 8 caterpillars of the third stage, while the adult male killed 5 caterpillars of the same stage every day.

This predator has been fed with armyworms, Asian corn borers, and rice leaf rollers, while the Miaoli Station has used the caterpillars of the Chinese cabbage butterfly, armyworms, silk worms, and maggots of the blowfly to feed this predator. The development period of the young stages ranges from 21 to 26 days. Since it is very convenient to purchase maggots from fishing gear stores compared to other food sources, they are used to feed this stinkbug in great numbers. The rearing containers are the same as those used to rear lacewings, so that the rearing costs for both predators can be reduced. The extension processes are the same as those of the lacewing. The Miaoli Station maintains a stock colony of this predator and provides egg masses to organic farmers.

Economic Benefits

During the peak extension period, more than 30 farmer associations adopted the lacewing as a biocontrol agent for spider mite control on papaya grown inside net houses. The cost per hectare for the conventional chemical application on papaya was NT$ 12,000 (US$ 1 ≈ NT$ 34), but it only cost NT$ 3,900 for releasing lacewings to control spider mites on papaya. As a result, using lacewing as a biocontrol agent for spider mites control on papaya can save a farmer up to NT$ 100,000 annually compared to chemical control. Using lacewing

on strawberry to control spider mites may be NT$ 6,000/ha less than conventional chemical control methods. Strawberry farmers can save NT$ 80,000/ha each year when they use lacewing instead of chemicals for spider mite control. In addition, the percentage of malformed strawberry fruit decreased 6.1%, and the highest-grade fruit increased 7.7% because of the more-successful pollination of flowers due to reductions in chemical applications. The strawberry farmers can increase their income by NT$ 20,000/ha each year. Using lacewing on leaf vegetables for the control of aphids can save the farmer NT$ 15,000/ha as compared with the cost of conventional chemical control.

Conclusions

It usually takes a long time for agricultural researchers to develop a practical technology for farmers. But for researchers, it may be even more difficult to successfully transfer the technology to farmers. First, the extension agent has to convince farmers that they can make a profit by implementing the new technology. Thus a demonstration farm has to be established on site. Second, the government has to provide incentives for farmers to implement the new technology. In Taiwan, in order to encourage reduced application of agrochemicals on crops, the central government provides subsidies for individual farmers to rear natural enemies as biocontrol agents. Research stations then provide free stocks of natural enemies for interested framers to reproduce more individuals to use in the field. Unfortunately, once the government withdraws the subsidies, some farmers are reluctant to continue to implement biocontrol strategies for insect pest control.

References

1. Chang, C. P. 2000. Investigation on the life history of *Mallada basalis* (Walker) (Neuroptera: Chrysopidae) and the effects of temperatures on its development. Chinese J. Entomol. 20: 73-87. (in Chinese)
2. Chang, C. P. and F. K. Hsieh. 2001. Predatory capacity of the predatory stink bug, *Eocanthecona furcellata* (Wolff) (Hemiptera: Pentatomidae) on various prey. Chinese J. Entomol. 21: 257-267. (in Chinese)
3. Chang, C. P. and S. C. Huang. 1995. Evaluation of the effectiveness of releasing green lacewing, *Mallada basalis* (Walker) for the control of tetranychid mites on strawberry. Plant Prot. Bull. 37: 41-58. (in Chinese)

4. Chang, C. P., F. K. Hsieh, and L. R. Hsu. 1994. Studies on influence of several pollens on oviposition and longevity of *Mallada basalis* (Walker) adults. Chinese J. Entomol. 14: 144-145. (summary)
5. Chu, Y. I. 1975. Rearing density of *Eocanthecona furcellata* (Wolff) with special consideration to its mass production. Rostria 24: 135-140. (in Japanese)
6. Chu, Y. I. and C. M. Chu. 1975a. Life history and the effect of temperature on the growth of *Eocanthecona furcellata* (Wolff). Plant Prot. Bull. 17: 99-114. (in Chinese)
7. Chu, Y. I. and C. M. Chu. 1975b. Feeding habit of *Eocanthecona furcellata* (Wolff). Plant Prot. Bull. 17: 133-141. (in Chinese)
8. Lee, S. J. 1979. Biology and population ecology of *Paurocephala psylloptera* Crawford and its predator, *Chrysopa boninensis* Okamoto. MS thesis, National Chung Hsing University, pp. 69. (in Chinese)
9. Leu, W. T. 1995. Technical improvements for group-rearing larvae of *Mallada basalis* (Walker) (Neuroptera: Chrysopidae). Chinese J. Entomol. 15: 11-17. (in Chinese)
10. Nee, H. H. 1983. Life history, predation and population increase of *Chrysopa boninensis* Okamoto and its prey, *Myzus persicae* Sulzer. MS thesis, National Chung Hsing University, pp. 64. (in Chinese)
11. Metcalf, R. L. and W. H. Luckmann. 1994. Introduction to Insect Pest Management. J. Wiley, New York.
12. Okada, T. and H. Kobayashi. 1997. Rearing methods of native natural enemies in Japan: rearing of the asopin bug, *Eocanthecona furcellata* (Wolff). Plant Control 51: 11-13.
13. Peng, Y. K. 1985. Field release of *Chrysopa sinica* as a strategy in the integrated control of *Panonychus citri*. Chinese J. Entomol. 1: 2-7. (in Chinese)
14. Semillano, N. S. and F. M. Corey. 1992. The life history of the predatory bug, *Eocanthecona furcellata* (Wolff), using the larvae of two lepidopterous insect pests as host. CMU J. Sci. 5: 16-33.
15. Tzeng, C. C. and S. S. Kao. 1996. Evaluation on the safety of pesticides to green lacewing, *Mallada basalis* larvae. Plant Prot. Bull. 38: 203-213. (in Chinese)
16. Wu, T. K. 1992. Feasibility of controlling citrus red spider mite, *Panonychus citri* (Acarina: Tetranychidae) by green lacewing, *Mallada basalis* (Neuroptera: Chrysopidae). Chinese J. Entomol. 12: 81-89. (in Chinese)
17. Yasuda, T. and S. Wakamura. 1992. Rearing of the predatory stinkbug, *Eocanthecona furcellata* (Wolff), on frozen larvae of *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae). Appl. Entomol. Zool. 27: 303-305.